INSTRUCTIONS FOR USING

DOLMAN'S

...NEW...

DECIMAL SCALE MEASURE.

PROTRACTOR.

INSTRUCTIONS FOR USING

DOLMAN'S

...NEW...

DECIMAL SCALE MEASURE PROTRACTOR.

This protractor produces length and position of all lines and degrees of angles required by algebra and calculus by practical object lessons in scale measure, thereby solving millions of problems by measurement in constructive geometry without algebra or calculus.

DESCRIPTION AND USE OF DOLMAN'S NEW DECIMAL SCALE MEASURE PROTRACTOR.

This protractor is a semi-circle with the semi-circumference of the protractor graduated 90 degrees from OM line to the right, and left to the bottom line DD of the protractor. The OM, or meridian line, meets bottom line, DD, at the middle, and in the centre of the small semi-circle and at right angles to line DD.

The two arms, BB, BB, must be fastened by a needle at the intersection of lines DD and O. M. in the small semi-circle. A parallelogram two by four inches, is cut out of the middle of the protractor parallel to sides LL, LL and DD, DD, and from equi-angular parallels, and by revolving the protractor one-half around, using the needle as a pivot, a four inch square, and a circle can be formed with a common centre to square and circle. The movable bar, DD, moves parallel to bottom line, DD.

An elastic scale, seven inches long, is for measuring arcs, or any other measurement of lines. The inside edges are graduated to twenty spaces to one inch, and sides LL LL read from one at bottom line, DD, up to 200 on outside lines, and 40 on inside lines.

Bottom and top lines, DD DD, read right and left from OM line 200 on outside lines and 40 on inside lines. Arms BB BB read from center needle outward 350 on outside lines and 70 on inside lines. All in edges are graduated to twenty spaces to one inch. The graduations of degrees on the semi-circle are not units of length. Their departure of length of arc depends on the length of the sides and number of degrees of the angle.

USE OF THE DECIMAL SCALE MEASURE PROTRACTOR.

This protractor measures degrees of angles and gives the length of every line to scale measure, and is a guide to draw every line by, without calculating the length of any lines. No other instrument in use at this time gives degrees of angles, length of lines and a guide to draw the lines of every polygon.

Decimal is a scale of which the order of progression uniformly is ten. A scale is a system of measurement that small spaces are used to represent larger units of measure and greater numbers of units proportionally, viz: To represent large area on small space, as maps, charts, plots, diagrams, &c.

A decimal scale progresses thus: If one-tenth of one inch represents one unit, one inch in length would represent ten units of length, and one square inch would represent one hundred squares of one-tenth of squares of one square inch, and ten square inches, or 3 16-100 inches square would represent one thousand one-tenths of inches in two dimensions. If we assume that one-tenth of one inch of scale in one dimension shall represent $1,000, then one inch in one dimension would represent $10,000, and one square inch in two dimensions would represent $100,000, and ten square inches, or 3 16-100 square would represent $1,000,000, and one hundred square inches, or ten inches square would represent $10,000,000, and one thousand square inches, or

31 62-100 inches square would represent $100,000,000, and ten thousand square inches, or one hundred inches square, would represent by scale measure, $1,-000,000,000.

The above explanation of decimal scale measure as applied to quantity, by numbers of units compared with extension of lines and angles are given to assist the mind to comprehend quantity and magnitude as multiplied by 10, 100, 1,000 &c.

Arithmetic is the science of numbers applied to units of quantity.

Geometry is the science of measurement.

Measurement is, first, ascertaining the number of units in a line by comparison in extension in one dimension called distance; second, by comparing square units with area in two dimensions called square measure; third, by comparing square units with thickness extension in three dimensions called cubic measure.

Algebra is the science of ascertaining unknown numbers of units of quantity by subtracting one known number of units from other known numbers of units, or by adding, multiplying or dividing or all combined.*

The following tables of units are in common use in the United States, and are in the arithmetic, viz: First, units of length, as inches, feet, miles, &c. Second, units of area, or square units, as square inches, square feet, square acres, &c. Third, units of volume, or cubic measure, as cubic inches, cubic feet, &c. Fourth, units of angles 360 degrees in every circle, and each degree may be considered an angle; 21,600 minutes in every circle, and each minute may constitute a separate angle. Every circle is divisible into (1,296,000) one million two hundred and ninety-six thousand angles of one second each, or any number less than the angular space may be an angle. Fifth, units of gravity (weight) determined by comparing the volume of water as a standard of 27⅞ cubic inches of water equals one pound avoirdupois weight and also equals one pint of liquid measure.

The Winchester Bushel contains 2150 42-100 cubic inches, or 77 627-1000 pounds of water avoirdupois, or 5760 grains apothecary weight.

One ounce of Troy equals 480 grains, and also equals 437½ grains avoirdupois weight.

Sixth, units of duration of time determined by motion of the planets, and are units of seconds, minutes, hours, days and years.

Seventh, units of value are created by law, and may be cents and dollars, shillings and pence, or any other unit desired. Degrees of angles have no proportion of length as to scale measure of departure of the arc of any angle. The right angled triangle is a unit of comparison of degrees of angles, and measured departure of angles.

Every right angled triangle is the one-half of a square, provided the two short sides of the triangle are of equal length, and one angle of the triangle will contain 90 degrees, if the short sides of the right angled triangle are of different length, the triangle is the one-half of an equiangular parallelogram.

A right angle has two sides and always contains 90 degrees, no more, no

*The remainder after subtraction is the unknown quantity.

less.

Every right angled triangle has three sides and three angles, and one of the angles is always equal to 90 degrees, and the other two angles are equal to 90 degrees.

Every equilateral triangle has three sides of equal length, and three angles of 60 degrees each.

Every scalene triangle has three sides of unequal length and three angles, and the three angles combined equal 180 degrees, and the scalene triangle can always be divided into two right angled triangles of unequal dimensions.

Problems have but one demand—that is how much—and that demand is satisfied by adding quantity to quantity, or by subtracting quantity from quantity.

All lines must have position, and that position and the relation to the position of other lines give names to the lines and cause the names of lines to change.

The triangle, square and hexagon, are the only regular polygons by which the angular space about a point can be completely filled up.

Quantity is a general term applied to every thing which can be increased, diminished, measured, compared, or estimatəd. It embraces numbers and magnitude.

DEFINITION.

RADII IS THE PLURAL OF RADIUS.

A radius is any straight line passing from the centre of the circle to the circumference of the circle.

Diameter is any straight line passing through the centre of a circle from one side of the circumference to the opposite side of the circle, or any polygon.

Circle, or circumference, is a line which is equal distance from a point within, called centre.

Perimeter, is any number of straight lines that enclose a polygon.

A polygon is any diagram with three or more sides.

A diagonal line is a straight line drawn from one angle to an opposite angle.

A vertex is the point where two lines meet, that form angles.

Base line, or meridian line, is the beginning line, or line that all other lines conform to.

A perpendicular line is a line that meets another line at right angle, called departure.

A hypothenuse line is the longest line of every right angled triangle, and forms the third side of the triangle, and in surveying land is called the bearing line.

Co-tangent, is a line that will meet the tangent at right angle and starts from the same circumference 90 degrees from where the tangent starts.

Co-ordinate triangle, means another triangle of equal dimensions of the first triangle, and opposite to the first triangle.

Ratio, is that relation between two quantities which is expressed by the quotient of the first divided by the second. Thus the ratio of 4 to 12 is 12-4, or, 12 divided by 4, the ratio is 3.

A proportion is an equality of ratios.

Infinity in measurement is when two lines approach so near to each other that no perceivable difierence can be seen.

Inscribed means one polygon, or circle produced within another circle or polygon.

Described means a circle or polygon produced around another circle or polygon.

Application of the decimal scale measure protractor to the following five diagrams, as per instructions, will enable the student to determine quantities and magnitude by measurement without algebra, or intricate calculus:

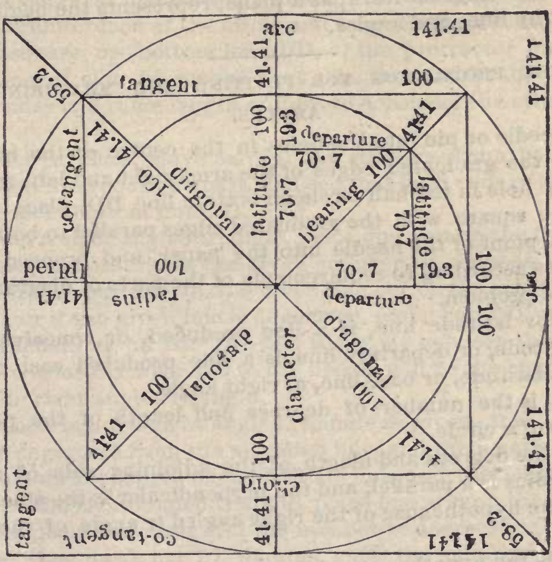


DIAGRAM NO. 1.

This diagram represents first a plane, second a sphere, third the proportion of area of a circle to the area of a square, which is, circle area,....7854

Area of square is, square...... 10000

The centre of this circle represents in geometry, first, the point of beginning of a space. Second, the centre of a sphere or the earth. The centre of

Square the two short sides, add their products and extract the square root of the product.

This earth is, in geometry, conceived to be the centre of space, and all conceivable lines that start from the centre of this earth are considered in geometry as perpendicular lines, and all lines produced at right angles to the perpendicular lines are considered as horizontal lines. The lines that are conceived to pass from the centre of the earth to its surface are represented by a plummet, and the horizontal lines are represented by the level, and are also called tangents, if continued in a straight line, and are known as apparent levels, or horizontal lines.

The lines produced on the circumference of the earth by the level when taken at different points of the earth's surface, produce circular lines, called true level, and are always at right angles to the plumb lines caused by the change of position of the level on the circumference of the earth as the level will be at right angle to every plumb line at every point of the earth's surface and the plumb line changes toward the centre of the earth when moved from one point to any other point on the earth's surface. Apparent level, or tangent lines only change four times, until they meet and form a square whose sides are equal in length to the length of the diameter of the inscribed circle.

The centre of diagram No. 1, as a plane, represents the beginning point of measurement by lines and angles.

TO ADJUST THE PROTRACTOR FOR PLOTTING AND MEASURING LINES AND ANGLES.

Insert a needle or pin into the holes in the centre of the half circles on BB, BB, with the graduated edges of the arms right and left, then insert the needle into the hole in the half circle on bottom line DD, place movable bar, DD, inside the square with the graduated edges parallel to bottom line, DD, then insert the point of the needle into the paper, and proceed to construct lines and angles according to requirements of the parts of diagram as required by terms of the problem.

Meridian. or latitude line, is a line produced, or conceived north and south. A longitude, or departure line, is a line produced east or west, and departs from a latitude, or base line, at right angle.

Sine of arc, is the number of degrees and length of the perpendicular line to a radius of a circle.

Co-sine, is the degrees and length of the adjoining side of the triangle of which the radius is a parallel, and the perpendicular is the sine.

Secant, is the hypothenuse of the right angled triangle of the radius and tangent.

Co-secant, is the hypothenuse of the complement angle.*

Tangent line, is a line that is produced at right angle to a radius, and if the secant is at an angle of 45 degrees to the tangent line, the tangent and radius will be of equal length. Otherwise, the tangent will be longer than

*When the degrees of an angle are subtracted from 90 degrees, the remaining degrees are called the complement; and when the degrees of an angle are subtracted from 180 degrees, the remainder is called the supplement angle. See co-sine, co-tangent, etc., in diagram No. 4.

the radius.*

To trace the lines of diagram No. 1, with the protractor as an object lesson in drawing, adjust the protractor as instructed. then insert the needle into the centre of diagram No. 1, place the bottom line, DD, of the protractor on one of the diameters of the circle and movable bar, DD, will be parallel with the tengents and chords of the square. Sides LL, LL, will be parallel at right angles to lines DD, DD, and arms BB, BB, will be movable to coincide with radius or bearing lines. Movable bar DD, will indicate departure, tangents and chords, and sides LL, LL, can be moved to indicate latitude and BB, BB, will represent meridian lines.

The OM line will always be at right angles to DD, DD, and parallel to LL, LL, and to mark opposite parallels must not be omitted when bearings change angles, and the protractor is to be moved to another bearing. The elastic scale will give the length of all lines and arcs to scale measure.

A thorough knowledge of geometry can only be acquired by producing lines and angles to scale measure.

To construct a circle, use a strip of card board for a radius, use a needle for a centre pivot, get the length of the radius from any part of the protractor, except the degrees; make a small hole in the card board for a pencil point to mark the circumference of the circle and a needle for a centre.

To form a square, use bottom line, DD, of the protractor one side of the square, and one of side LL for the next side, then invert the protractor and use the same sides and same length of lines to construct the other sides of the square.

To construct parallels, move bar DD the distance from bottom line DD that the parallels are required apart, and see that both ends of bar DD are the same distance from bottom line DD.

To construct a right angled triangle, place one arm on the OM line of the protractor, place the other arm the given number of degrees from the first arm, move parallel bar DD to the given number on the arm that represents the given line, or if the given line is departure, move bar DD until the given number of graduations on bar DD fills the space between the two arms BB, BB and the two arms from bar DD to the needle will be the length of the other two sides of the right angled triangle.

When the bearing of a right angled triangle is given, that is the number of degrees of departure from the meridian line, and the length of the bearing line given to obtain the length of the latitude line, and the length of the departure line of the right angled triangle, place one arm on the OM line of the protractor, and place the other arm the number of degrees to the right or left of the OM line, then move bar DD parallel until the number of graduations given is found on the arm that is not on the OM line, then the arm on the OM line between the bar and needle will be latitude, and the distance on bar DD between the two arms will be the length of departure, and the other arm will give bearing distance.

To construct an equilateral triangle, place one arm 30 degrees to the right

*Secant lines pass outside of the circle and meet the tangent line.

of the OM line and the other arm 30 degrees to the left of the OM line; move bar DD until the distance on bar DD is equal to the length on each arm. Then will the three sides be of equal length, and the three angles contain 60 degrees each. Move one arm to OM and it gives the perpendicular of the triangle.

To construct a tangent square, or described square, to a circle, construct two diameters at right angles to the circle, dividing the circle into four equal parts; place bottom line. DD and side LL on the outside of the circle, so that the length of the radius of the circle on DD and LL will meet two ends of the diameters will produce the first one-fourth of the square. Then move the protractor to the ends of the next diameters, and so on until the square is completed.*

A line from the centre of the circle to the angle of the described square of a circle will be a radius that will double the area of the first circle, and the diagonal of the described square will be the length of a square double the area of the described square.

RULES FOR CALCULATING LENGTH OF LINES, NUMBER OF SQUARE UNITS IN AREA AND CUBIC UNITS OF VOLUME.

The diameter of a circle given, required the length of the circumference of the circle.

RULE BY CALCULATION.

Multiply the length of the diameter of the circle by 3.1416; point off four figures on the right of the product for decimals, and the remaining figures will be whole units. The circumference of a circle given, required the diameter of the circle.

RULE BY CALCULATION.

Add four ciphers to the circumference, then divide by 3.1416, and point off four right hand figures for decimals in the quotient. The diameter of a circle given, required the area of the circle.

RULE BY CALCULATION.

Multiply one-half of the diameter by one-half of the circumference, or square the diameter of the circle, and multiply that product by the decimal .7854. Point off four right hand figures for decimals.

The two short sides of a right angled triangle given, required the area of the triangle.

RULE BY CALCULATION.

Multiply one short side by one-half the length of the other short side. The two short sides of a right angled triangle given, required the length of the bearing or hypothenuse.

RULE BY CALCULATION.

*See Diagram No. 1.

Square the two short sides, add their products and extract the square root of the product.

RULE BY PROTRACTOR.

Place one arm of the protractor on the OM line, place the other arm on the given number of degrees of departure of the angle, move bar DD parallel until the number given for latitude on first arm, and the other arm from needle to bar DD will be the length of the bearing line.

The diameter of a circle given, required the length of the side of the greatest inscribed square.

RULE BY CALCULATION.

Multiply the diameter by the decimal .7070, and cut off four decimals.

RULE BY PROTRACTOR.

Construct a circle, construct two diameters at 90 degrees, dividing the circle into four equal parts. The distance between any two ends of the diameters will be the length of the sides of the inscribed square. Straight lines drawn between the ends of the diameters will construct the inscribed square, and the four sides will be four chords to the four arcs made by the two diameters of the circle.

The length of the side of a square given, required the area of the square.

RULE BY CALCULATION.

Multiply the length of the side by its own length.*

The area of a square given required the area of a circle, whose diameter is equal to the side of the square.

RULE BY CALCULATION.

Multiply the area of the square by the decimal .7854, and point off four decimals on the right.

The diameter of a circle given, required the length of the side of a square whose area equals the area of the circle.

RULE BY CALCULATION.

Multiply the diameter of the circle by the decimal .8862, and cut off four decimals.

The length of the side of an equilateral triangle given, required the perpendicular of the triangle.

RULE BY CALCULATION.

Multiply the length of the side by the decimal .8660, and point off four decimals.

RULE BY PROTRACTOR.

Construct the triangle and measure the distance from any one of the angles to the center of the opposite side.

*To multiply a number by its own length is called squaring a number.

The circumference of a circle given, required the length of the side of a square equal in area to the area of the circle.

RULE BY CALCULATION.

Add three ciphers to the circumference, then divide by 4.442, and point off three decimals in the quotient.

The diameter, or base, and length of a cylinder given, required the volume or cubic contents.

RULE BY CALCULATION.

Multiply the square of the base by the decimal .7854, and that product by the height of the cylinder, point off four decimals.

The diameter and height of a cylinder given, required the superficial contents (area) of the cylinder.

RULE BY CALCULATION.

Multiply the diameter of the cylinder by 3.1416, and multiply that product by the height of the cylinder; point off four decicals, and that product will be the perpendicular superficial contents of the cylinder, less the two ends of the cylinder; multiply the squares of the diameter of the cylinder by two, and multiply that product by the decimal .7854; point off four decimals.

The area of a sphere is equal to the area of four circles, whose diameters are equal to the diameter of the sphere.

The diameter of a sphere given, required the area of the sphere.

RULE BY CALCULATION.

Square the diameter of the sphere, multiply that product by four, and multiply that product by the decimal .7854, and point off four decimals.

The area and diameter of a sphere given, required the volume, or cubic contents of the sphere.

RULE BY CALCULATION.

Multiply the area of the sphere by one-sixth of the diameter of the sphere.

The perpendicular of an equilateral triangle is three-fourths the length of the diameter of its described circle, and two-thirds the distance from the vertex to the opposite side on the perpendicular will be the centre of the described circle.

Multiply the length of the side of an equilateral triangle by twenty and divide that product by twenty-three. This will very nearly give the length of the perpendicular of the triangle.

RULE BY PROTRACTOR.

Measure the perpendicular of the triangle with the protractor.

The length of radius and degrees of arc given, required the length of the arc.

RULE BY CALCULATION.

Multiply the radius by 3.1416, divide that product by 180, and multiply that quotient by the number of degrees of the arc. This will givie the length

of the arc. Point off four decimals in the last product.*

Every square is divisible into two right angled triangles of equal dimensions and the two short sides of each triangle will be of equal length, and the diagonal line that separates the two right angled triangles will be the hypothenuse to both right angled triangles. If one short side of the right angled triangle is longer than the other short side of each right angled triangle, its polygon is an equiangular parallelogram.

The side of a sector whose angle is 60 degrees given, required the length of the arc.†

RULE BY CALCULATION.

Multiply the length of the side of the sector by 3.1416; divide that product by three, and point off four decimals in the product.

Co-ordinate angle means another angle equal to the first angle with opposite bearings.

The decimal scale measure protractor does not give area and volume of quantities. This protractor gives length of lines and degrees of departure of angles, and the form of all angles and diagrams.

All area and volume are ascertained by multiplying the length of a line by its own length, called squaring a line, and multiplying the square product by the thickness gives volume, or cubes.

Multiplying one long side by one short side gives area of equiangular parallelograms

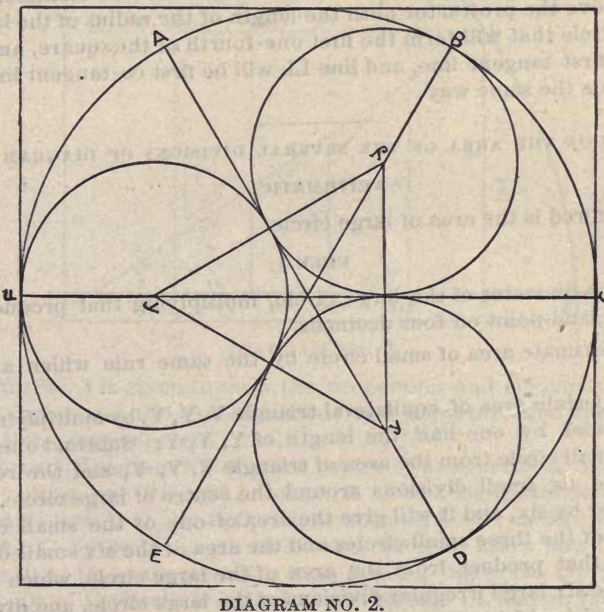


DIAGRAM NO. 2.

*Rule by Protractor.—Measure the arc with the elastic scale.

†Rule by Protractor.—Measure the arc with the elastic scale.

Diagram No. 2 is the base of the principle of algebra.

The length of the radius of the large circle of diagram No. 2 given, required the diagram by the protractor, and the area of each separate part of the diagram by simple calculation, viz: Addition, subtraction, multiplication and division.

RULE FOR PROTRACTOR.

Draw large circle, A, B, C, D, E, F, to given radius; divide large circle into six equal parts by constructing diameters, AD, BE, FC, 60 degrees in each division; place the centre of the protractor at D on large circle, and top of protractor, OM line, on A; move right arm 20 degrees to the right from OM line, and at the point that the arm crosses the second line, viz: BE will be the centre of first small circle; move left arm 20 degrees to the left of OM line, and where the left arm crosses the second line, FC, will be the centre of the second small circle; move centre of protractor to point B; move top of protractor, OM line, to E; move left arm 20 degrees to left of OM line, and the point on second line, DA, will be the centre of third small circle. Move right arm 20 degrees to the right of OM line, and the right arm will meet the centre of first small circle. If the diagram is correctly constructed, the lines Y B, Y D, and Y F, are the radii of the three small circles, and all the straight lines of the diagram can be measured by the protractor to form the tangents or described square around the great circle. Place bottom line DD and side LL on the outside of large circle, placing side DD at either diameter on large circle and move the protractor until the length of the radius of the large circle meets the circle that will form the first one-fourth of the square, and the line DD will be first tangent line, and line LL will be first co-tangent line. Form other tangents the same way.

CALCULATION OF THE AREA OF THE SEVERAL DIVISIONS OF DIAGRAM NO. 2 BY ARITHMETIC.

First required is the area of large circle.

RULE.

Square the diameter of the large circle, multiplying that product by the decimal .7854, and point off four decimals.

Second, estimate area of small circle by the same rule which applies to large circle.

Third, ascertain area of equilateral triangle Y, Y, Y, by multiplying length of perpendicular by one-half the length of Y, Y, Y. Subtract one-half the area of one small circle from the area of triangle Y, Y, Y, and the remainder will equal the six small divisions around the centre of large circle. Divide that remainder by six, and it will give the area of one of the small divisions. Add the area of the three small circles and the area of the six small divisions, and subtract that product from the area of the large circle, which will give the area of the six large irregular divisions of the large circle, and divide that remainder by six, which will give the area of one of the large irregular divis-

ions of the circle. Subtract the area of the large circle from the area of the described square. The remainder will equal the four irregular divisions of the square. That remainder divided by four will give the area of one of the four irregular divisions of the square.

Careful inspection of instructions given for diagram No. 2 will show that the twelve irregular divisions of the large circle can not be measured. The only process to obtain their area is to subtract one known area from another known area, either by arithmetic or by algebra.

The equilateral triangle, Y, Y, Y, separates the sector, or one-sixth part of the area of each of the three small circles; hence, three-sixths equal one-half of the area of one small circle, and the remainder of the area of triangle Y, Y, Y, equals unknown quantities of the six small divisions, and the six large divisions and four divisions of the square are obtained by the same rule.

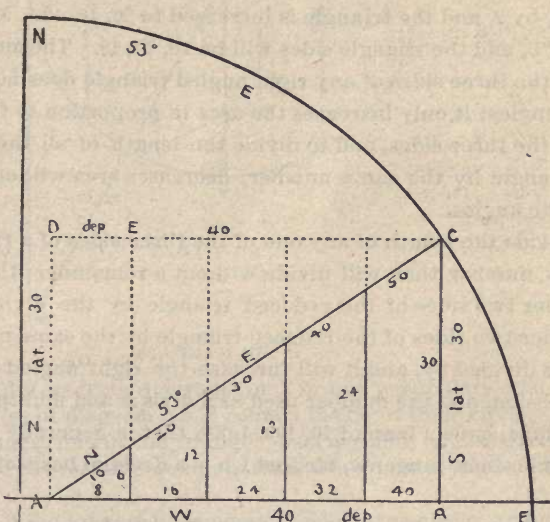


DIAGRAM NO. 3.

Diagram No. 3 is given to show the proportion and similarity of all right angled triangles and the use of latitude and departure and the principle of longitude sines, tangents, etc.

To construct Diagram No. 3, place centre of protractor at A and OM line on D, and bottom line DD will be on A, B. Place right arm on C, 53 degrees from meridian line A, D, N; A, C, will be bearing north, and 53 degrees east. Let line A, C, be 50 in length to C. We want to know how far south it is from* C to B, and how far west it is from B to A. Move bar DD parallel to C, and line A, D, will indicate 30 latitude north on side LL and on the arm placed

*Latitude south, departure w .

on OM line on line A, D, N, and bar DD will indicate 40 east from D to C. Move the protractor centre to C, place line DD of protractor on D of diagram and OM line on C, B. Move bar DD parallel to A, B; then will C, B indicate south latitude from C to B, and bar DD will indicate west departure 40 from B to A. The solid line, A, C; C, B; B, A, may represent a right angled triangle of land, or any other quantity of area and the length of the lines may represent feet, miles, or any other units of measure. The dotted lines A, D; D, C; C, A, represent the co-ordinate triangle A, D, C, and the arc N, C, E represents the one-fourth of a circle or 90 degrees from meridian line A, D, N, to east line A, B, E, and C, A will be bearing south 53 degrees, west, 50.

The five divisions of equal distance in triangle A, C, B, are given to show the similarity of right angled triangles. Multiply the three sides of the first triangle, 10, 8, 6, by 2, and the triangle is increased to 20, 16, 12. Multiply triangle 10, 8, 6, by 3, and the triangle sides will be 30, 24, 18. The multiplication of the length of the three sides of any right angled triangle does not alter the degrees of the angles; it only increases the area in proportion to the increase of the length of the three sides, and to divide the length of all the sides of a right angled triangle by the same number, decreases area without changing the degrees of the angles.

Hence, to divide the length of any one of the three sides of a right angled triangle by any number that will divide without a remainder; then find the length of the other two sides of the reduced triangle by the division. Then multiply the other two sides of the reduced triangle by the same number that the first side was divided by, and it will increase the right angled triangle to its original dimension, and the number used as a divisor and multiplier will be a base. (Logrithms, have a base of 10, 100, 1,000, that is generally used as a basis of logrithmic sines, tangents, etc., which is a decimal basis of the radius of a circle.)

Take C as beginning of diagram No. 3; then line C, A, would read south 53 degrees, west, 50. By application of the protractor to the lines, would show that angle A, B, C is 37 degrees, which would also be found by subtracting 53 degrees from 90 degrees. Thirty-seven degrees are the complement of 53 degrees. A, B would be departure east 40, and B, C, would be latitude north 30 degrees.

The area of triangle A, B, C, is found by multiplying line A, B, by one-half of line B, C, or multiply one short side of the triangle by one-half of the other short side. See rule.

The elastic scale will measure the length of arc N, C, and arc C, E. See rule for finding length of arc by protractor and by calculation.

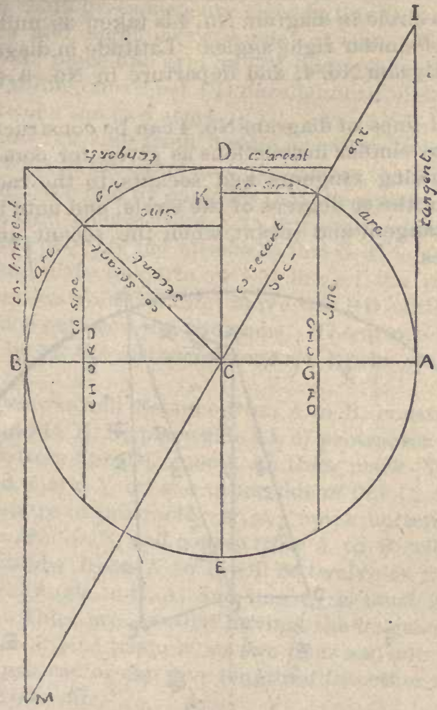


DIAGRAM NO. 4.

Diagram No. 4 differs from diagram No. 3 in two particulars, viz:

First, all the lines of diagram No. 3 remain inside of their circle.

Second, the longest line of the triangle (bearing line) and degrees of angle are given to find the latitude and departure of two short lines of the right angled triangle.

In diagram No. 4 the longest lines pass outside of the circle, and are called tangent, co-tangent, secant, and co-secant, and the shortest sides never pass outside of the circle, and are given with length and the degrees of angle to find the length of the long lines. The two short sides are called sine and co-sine, and the length of tangent and secant increase of the number of degrees of sine of arc increase, and decrease in the same way, when co-sine and tangent increase.*

At an angle of 45 degrees, sine and co-sine are of equal length; tangent and co-tangent are of equal length, and secant and co-secant are of equal length.

At 90 degrees the bounds of the triangle are reached by either sine or co-sine, and is called infinity. See definition of infinity.

*See diagram No. 4.

The radius of the circle in diagram No. 4 is taken as unity, and sine and tangent form sides of similar right angles. Latitude in diagram No. 3 corresponds with sine in diagram No. 4, and departure in No. 3 corresponds with co-sine in No. 4.

The length of all lines of diagram No. 4 can be constructed and measured with the protractor by similar instructions as given for constructing diagram No. 3. Practice drawing tangents and secants to the radius of a circle to every five degrees of the 90 degrees of the circle, and note the rapid increase in the length of the tangent and secant when the secant and tangent angle approaches 90 degrees.

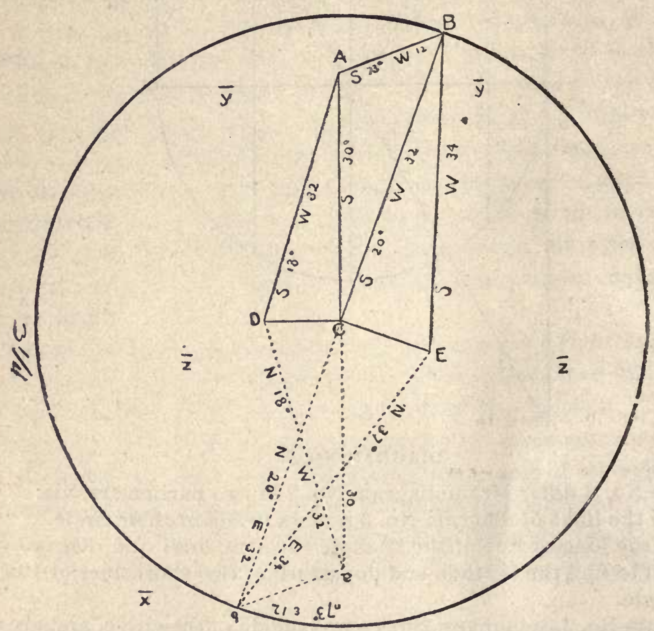


DIAGRAM NO. 5.

Diagram No. 5 is given to show how to obtain distance to inaccessible objects by the right angled triangle as given in co-sines in diagram No. 4 C is first point of observation; A is first inaccessible object; D is second point of observation to object A. C is first point of observation to B, or second inaccessible object, and E is second point of observation to object B. Required the distance from C to A and the distance from C to B and the course and distance from A to B.

We have a compass to give angles,* and chain to give distance, C, D, the compass says, course C, A, is south, and the line D, A is south, 18 degrees

*Measured line must always be taken at right angle to the line from observation to object.

west, and the chain gives measure eight to line C, D. Now we have a co-sine of 18 degrees and eight measurement of sine. We now place centre of the protractor on A; place one arm on OM line; place the other arm on 18 degrees from OM line, move bar DD parallel until eight spaces on bar DD fills the space between the two arms.

The arm on OM line from needle or center to bar DD will be 30, the distance from C to A in the same unit of measure that C, D was measured with on the ground. We find by compass that the course from C to B is south, 20 degrees west, and course from E to B is south, seven degrees west, giving a co-sine of seven degrees and measured line C, E is 10. Place centre of protractor on B and place one arm on OM line of the protractor and the other arm seven degrees from OM line; move bar DD until 10 graduations on bar DD fill the space between the two arms. The arm on OM line from bar DD to centre will be 32, the distance from C to B; the other arm will give distance from E to B.

To obtain course and distance from A to B, construct right angled triangles C, D, A, and C, E, B; place side LL of protractor on line C, A; move protractor until bottom line DD meets A; then mark Y. Change sides of the protractor and mark Y on the other side of line C, A, and Y, Y is parallel to C, D. Place centre of protractor on A; move bottom line DD of protractor on Y, Y; place arm on B, and course from A to B will be south 73 degrees, west; and distance from A to B will be twelve on the arm. Line D, C must be taken at right angle to C, A, and line C, E must be constructed at right angle to C, B. Thus, we see that having the length of one line, and two angles of any right angled triangle, or two lines and one angle given, the decimal scale measure protractor can give length of the other two sides and angle, or two angles and one side.

The dotted lines in diagram No. 5, are given to show co-ordinate angles and opposite bearings of the diagram. To prove the angles A, C, D, and B, C, E, take same amount of distance and area of the circle, or opposite directions, that triangles C, E, a, and C, E, b take from the circle.

Any course may be taken from toint of observation. Measured line must always be constructed at right angle to object line. The names that line takes in the different diagrams should be remembered, to prevent error in calculation.

Note in plotting field notes of land opposite parallels must be made at every angle that is less or greater than 90 degrees, viz: First, to have a parallel mark to adjust the protractor at the next angle. Second, to find latitude and departure to the angle.

No survey is correct unless the lines close by latitude and departure, extend as far north as south, and as far east as west, called in surveying, northing and southing, and easting and westing.

This rule should be well understood. The bearing of a right angled triangle given, required the latitude and departure.

FIRST RULE BY PROTRACTOR.

Place one arm on OM line and place the other arm on the number of de-

grees of departure of the angle; move bar DD parallel to the number on the arm that is not on the OM line, and bar DD will be departure, and the arm on OM line will be latitude.

The latitude and degrees of departure of a right angled triangle given, required the bearing and departure of the right angled triangle.

SECOND RULE BY PROTRACTOR.

Form right angled triangle on protractor, and the arm on OM line will be latitude, bar DD will be departure, and the other arm will be bearing.

The departure of a right angled triangle and degrees of departure of the angle given, required the latitude and bearing of the right angled triangle.

THIRD RULE BY PROTRACTOR.

Form triangle as before. The first rule applies to line A, C, diagram No. 3. Rule second applies to perpendicular in triangle, diagram No. 2, and line A, B, in diagram No. 3, and tangent A, I in diagram No. 4, and lines C, A, and C, B, diagram No. 5.

Third rule applies to co-sine in diagram No. 4, etc. Line C, D and C, E in diagram No. 5 coincides with co-sines in diagram No. 4 and line C, B, in diagram No. 3..

Dolman's New Decimal Scale Measure Protractor, patent June 10th, 1890, produces length and position of all lines and degrees of angles required by arithmetic, algebra and calculus by practical object lessons scale measure, thereby solving millions of problems by physical measurement in constructive geometry without the assistance of algebra and intricate calculus.

This protractor conveys the idea of numbers and magnitude as applied to practical architecture, mechanics, land surveying, civil engineering, navigation, mine surveying, irrigation, hydrography and astronomy.

This protractor is a complete drafting outfit for the student, and when made of metal and graduated to 100 to 1 inch with vernier to read minutes, it is the best and most convenient practical protractor in use. The Decimal Scale Measure Protractor gives double parallel lines and when connected form right angles.

All angles of every polygon that are less or greater than right angles must have a right angled triangle constructed or conceived to that angle before the area of that polygon can be ascertained, and the area of the constructed right angled triangle must be ascertained separate from the area of the other parts of the polygon, and added to complete the area of the polygon.

When constructing polygons with the protractor, every angle of the polygon that is less or greater than a right angle must have a latitude and departure line ascertained by leaving the bearing arm on the line of the polygon, then place the other arm on the OM line of the protractor; move bar DD parallel until the end of the line is met by bar DD. The distance between the two arms on DD will be departure, and the distance from the centre will be the latitude and departure of every right angled triangle. The latitude and departure of every right angled triangle are the two short sides of the triangle.

When the protractor's centre is moved to the end of the line to construct another line and angle to the polygon, the bottom line DD must be placed on the departure line to preserve the parallels to the meridian or base line of the polygon, and when the course reverses, the top of the protractor must be turned one-half around, so that the parallels may not be lost in returning to the beginning point of the polygon.

No polygon is completed until the last line meets the beginning point (called closing the survey or polygon.)

The latitude and departure lines of a polygon should be indicated by dotted lines, and the length of the latitude and departure lines should be noted, that the area of the triangle may be computed.

The latitude and departure should be on the outside of the polygon to continue the parallels with the protractor. Co-ordinate latitude and departure lines may be constructed on the inside of the polygon to prevent confusion and error by adding area to the polygon whose angles of the polygon are less than right angles.

The length of either side of a right angled triangle of any conceivable length may be reduced by dividing the length of the side of the triangle by any number that will divide it without a remainder, to a number less than the graduations on the protractor; then find the other two sides of the triangle on the protractor, and multiply the two sides thus found on the protractor by the same number that the side of the large triangle was divided by. This will give the length of the other two sides of the large triangle, which is all there is in similar right angled triangles of latitude and departure, logrithmic sines, tangents, etc.

Dolman's New Decimal Scale Measure Protractor produces length and position of all lines and degrees of angles required by arithmetic, algebra, and calculus by physical lines and angles, solving and proving millions of problems.

The question is asked "How does the Decimal Scale Measure Protractor solve and prove an infinite number of problems?" We answer that the right angled triangle is a unit of comparison of measure between regular and irregular polygons.

All polygons are divisible into some number of right angled triangles of equal or different dimensions, and to multiply one short side by one-half the other short side of any right angled triangle gives the area of the triangle.

The Decimal Scale Measure Protractor can be made to give the length of all three sides and the three angles to every right angled triangle if the length of one side and one angle are given.*

All areas are determined either directly or indirectly by multiplying one short side of a right angled triangle by one-half of the other short side. See rule.

Multiplying the length of a line by its length gives the area of a square whose side equals the length of the line, and whose area is equal to the two

*The right angle is always understood without giving it when a right angled triangle is given.

right angled triangles of that square, and the same rule applies to equiangular parallelograms.

The Decimal Scale Measure Protractor gives double parallel lines to a meridian or base line, and donble parallel lines form right angles.

All angles of every polygon that are less or greater than right angles must have a right angled triangle constructed to that angle before the area of that polygon can be ascertained, and the area of the constructed right angled triangle must be ascertained separate from the area of the other parts of the polygon and added to complete the area of the polygon.

When constructing a polygon with the protractor, every angle of the polygon that is less or greater than a right angle must have a latitude and departure line ascertained by leaving the bearing arm on the line; then place the other arm on the OM line and move bar DD parallel until the end of the line of the polygon is reached. Then the distance between the two arms will be the departure and the distance from the centre to bar DD will be the latitude of the right angled triangle. The latitude and departure of every right angled triangle is the two short sides of the triangle. When the centre of the protractor is moved to the end of the line to construct another side and angle to the polygon, the bottom line DD must be placed on the departure line last made to preserve the parallels to the meridian or base line, and when the course reverses, the top of the protractor must be turned one-half around, so that the parallels may not be lost in returning to the beginning point of the polygon or survey. No survey, or polygon is correct unless the lines close by latitude and departure. The latitude and departure lines of a polygon should be designated by dotted lines, and the length of latitude and departure should be noted, that the area of the triangle may be computed.

The versed sine, or perpendicular line between arc and chord, is changeable in length, viz: First, the length of the versed sine is always equal to the difference in the length of the two longest sides of the right angled triangle. Second, when the length of the sine is added to the length of latitude, their sum would equal the radius of their circle. Third, when the versed sine is added to the one-half diagonal of an inscribed square, that line will equal the radius of a circle that will describe the inscribed square, and the area of the last circle will be double the area of the first circle; and the area of inscribed and described circles can be doubled, and the area of inscribed and described squares doubled ad infinitum. See diagram No. 1.

The length of either side of a right angled triangle of any conceivable length may be reduced by dividing the length of the side of the triangle by any number that will divide it without a remainder to a number less than the number of graduations on the protractor; then find the other two sides of the triangle on the protractor and multiply the two sides thus found on the protractor by the same number that the side of the large triangle was divided by and it will give the length of the other two sides of the large triangle, which is all there is in similar right angled triangles of latitude and departure, logrithmic sines, tangents, etc.

Dolman's New Decimal Scale Measure Protractor produces length and position of all lines and degrees of angles required by arithmetic, algebra and

calculus by physical lines and angles; solving and proving millions of problems.

TEXAS LAND MEASURE TABLE.

The Standard of Texas Land Measure is the 10 vara chain containing 50 links.

$6\frac{2}{3}$ inches equals 1 link.
1 vara equals 5 links.
$33\frac{1}{3}$ inches equal 1 vara.
237 2-10 varas equal $\frac{1}{8}$ mile.
475 2-10 " " $\frac{1}{4}$ "
950 4-10 " " $\frac{1}{2}$ "
1900 8-10 " " 1 "
75 13-100 " " side of 1 acre.
1000 " " " " 1 labor.
4080 2-10 " " " " $\frac{2}{3}$ league.
3555 5-10 " " " " $\frac{1}{2}$ "
2886 " " " " $\frac{1}{3}$ "
2500 " " " " $\frac{1}{4}$ "
5000 " " " " 1 "
1344 " " " " $\frac{1}{2}$ section.

NUMBER OF SQUARE VARAS IN SURVEYS.

25,000,000 sq. varas equal 1 league.
16,666,666$\frac{2}{3}$ sq. " " $\frac{2}{3}$ "
12,500,000 " " " $\frac{1}{2}$ "
8,333,333 " " " $\frac{1}{3}$ "
6,250,000 " " " $\frac{1}{4}$ "
1,000,000 " " " 1 labor.
3,613,040 " " " 1 section.
1,806,520 22-100 sq. va. equal $\frac{1}{2}$ section.
903,260 16-100 " " " $\frac{1}{4}$ "
451,630 8-100 " " " $\frac{1}{8}$ "
602,173 44-100 " " " 1-6 "
5,645 " " " 1 acre.
4428 697-1000 acres " " 1 league.
177 " " 1 labor.
$1111\frac{1}{2}$ sq. in. equal 1 square vara.
7 sq. ft. & $103\frac{1}{3}$ sq. in. equal 1 sq. vara.

TABLE OF THE GEOGRAPHICAL MILES IN A DEGREE OF LONGITUDE AT EVERY DEGREE OF LATITUDE ON THE TERRESTRIAL SPHEROID, THE ELLIPTICITY BEING ASSUMED 1-300.

Lat.	1° Long.	Lat.	1° Long.	Lat.	1° Long.
°	Miles.	°	Miles.	°	Miles.
0	60.000	30	52 004	60	30.074
1	59.991	31	51.475	61	29 162
2	59.963	32	50 929	62	28 241
3	59.918	33	50 369	63	27 311
4	59 855	34	49 793	64	26 373
5	59 773	35	49 202	65	25 426
6	59.673	36	48.596	66	24 472
7	59 556	37	47 975	67	23 510
8	59 421	38	47 339	68	22 541
9	59 267	39	46 689	69	21 565
10	59.095	40	46.025	70	20 581
11	58.905	41	45.346	71	19 592
12	58.698	42	44 654	72	18.596
13	58 472	43	43 948	73	17 595
14	58 229	44	43 228	74	16 589
15	57.969	45	42 496	75	15.576
16	57.690	46	41.750	76	14.560
17	57.395	47	40.991	77	13 539
18	57.081	48	40 220	78	12.514
19	56.751	49	39 437	79	11.485
20	56 403	50	38 641	80	10.452
21	56 038	51	37.834	81	9.416
22	55.656	52	37 014	82	8 378
23	55.258	53	36.184	83	7 337
24	54.842	54	35 342	84	6 293
25	54.411	55	34 491	85	5 247
26	53 962	56	33 628	86	4.199
27	53.497	57	32.754	87	3.149
28	53 015	58	31 870	88	2.100
29	52 518	59	30 977	89	1.050
30	52 004	60	30 074	90	0.000

To reduce equatorial miles to statute miles:

RULE.—Multiply the equatorial miles by 69 1-6 and divide the product by 60.

To reduce varas to acres,

RULE.—Multiply the numbes of varas by $177\frac{1}{8}$, cut off 6 decimals from the product, the remaining figures of the product will be acres and the decimals will be fractions of an acre; or divide number of square varas by 5,645.

Measure all lines of the diagram with the protractor to learn its use.

Every School Teacher, Mechanic and Scholar should have one of these protractors with which to practice drafting.

The Wise County Protractor Publishing Co., want an agent in every city, town and county in the U. S. to sell Dolman's Protractor.

Reserved territory and a liberal commission given to agents. Write for special terms to J. H. Dolman, Abilene, Texas., General Agent.

The price of the protractor is $1, postage free. Address all orders for protractors to Roy B. Bradley, Abilene, Texas.

HATHAWAY'S IMPROVED TRAVERSE TABLE, WITH RULES FOR OBTAINING NATURAL SINES, TANGENTS, ANGLES, ETC

Holman's New Decimal Scale Measure Protractor is graduated to degrees and whole units of linear measure. The following rules and table are given with reference to the application of the Scale Measure Protractor to diagrams Nos. 3 and 4 in instructions for using the Protractor in constructive geometry and trigonometry. The table shows latitude and departure to four decimal places for linear bearing 1.00 and for angular bearings from 0 to 90 degrees.

If the angular bearing is less than 45 degrees the angle will be found in the 1st., 5th., or 9th. column of the table and the linear bearing at the top or bottom of the column; the latitude will be found in the column headed lat. at the top of the table, and the departure in the column headed dep.

If the angular bearing is more than 45 degrees the angle will be found in the 4th., 8th. or 12th. column of the table The latitude will be found in the column marked lat. at the bottom, and the departure in the column marked dep at the bottom. The latitude, departure and linear bearings for different distances with the same angular bearings are proportional. Linear bearing = unity, radius, secant and co secant. Latitude = natural sines and tangents. Departure = cosines and co-tangents. Verse sine = the difference in linear bearing and latitude Angular bearings = the number of degrees minutes and seconds that measure the angle.

EXAMPLE FIRST.

Example 1st: Given the angular bearing 11 degrees and 45 minutes and linear bearing 31: required the latitude and departure of the triangle Rule 1st.: In the table opposite 11 degrees 45 minutes we find the decimal .9790 in the latitude column and decimal .2036 in the departure column. Multiply .9790 by bearing 31 = 30.3490; and 2036 by 31 = 6.3116 required latitude and departure.

EXAMPLE SECOND

Example 2nd: Required the latitude and linear bearing to given linear departure 25 and the angular bearing 19 degrees and 15 minutes. Rule 2nd: In the table opposite to 19 degrees and 15 minutes we find decimal .9441 in the latitude column and .3297 in the departure column Divide the given departure 25 by .3297 =75.8265 the required bearing. Multiply 75 8265 by .9441 = 71 5877 latitude required.

EXAMPLE THIRD

Example 3rd: Latitude 16 34 and angular bearing 37 degrees and 30 minutes given: required linear bearing and departure. Rule 3rd: In the table opposite to 37 degrees and 30 minutes in latitude column we find decimal .7934 and .6088 in departure column. Divide the given latitude 16.34 by .7934 = 20 5949 the required bearing, and multiply the linear bearing 20 5949 by .6088 = 12.5381 the required departure.

EXAMPLE FOURTH. Bearing 600

Example 4th : Given linear bearing 600 and linear departure 100: required the angular bearing. Rule 4th: divide the given departure 100 by given [redacted] 600 =.1666. In the table we find the nearest number to the quotient to be the decimal .1650 opposite to 9 degrees and 30 minutes, and .1693 opposite to 9 degrees and 45 minutes, subtracting the quantities we have 15 minutes equals .0043; divide .0043 by 15 minutes equals .00028666 the tabular difference for 1 minute. Subtract .1650 from 1666 equals 0016 divided by .00028666 equals 5.5815 minutes. .5815 multiplied by 60 equals 34.89 seconds. Combining the quantities we have 9 degrees, 35 minutes and 34.89 seconds for the required angular bearing.

EXAMPLE FIFTH.

Example 5th: First operation: Required the verse sine, (the verse sine is the difference between the latitude and linear bearing) for linear bearing 31 and angular bearing 11 degrees and 45 minutes. By rule 1 we find the latitude to be 30.3490 subtract, and the difference .6510 is the verse sine: Second operation: required co-tangent to the same linear and angular bearing The given bearing 31 becomes latitude and is worked by rule 3rd. The co-tangent is 6 4469 and the co-secant 31.6650; third operation: required the natural tangent and secant to the same linear and angular bearing. Substitute the linear bearing 31 for latitude to natural tangent and secant. The angular bearing of the tangent and secant is found by subtracting the given angle 11 degrees and 45 minutes from 90 degrees equals 78 degrees and 15 minutes, therefore read the columns from the bottom and proceed as in rule 3rd. tangent is 149.0618, and the secant 152.2593.

The latitude and departure given to find linear bearing: rule square the latitude and departure add them and extract the square root.

Course.	Dist. 1.			Course.	Dist. 1.			Course.	Dist. 1.		
° '	Lat.	Dep.		° '	Lat.	Dep.		° '	Lat.	Dep.	
0 15	1.0000	0.0044	45	15	0.9648	0.2630	45	15	0.8638	0.5038	45
30	0000	0087	30	30	9636	2672	30	30	8616	5075	30
45	0.9999	0131	15	45	9625	2714	15	45	8594	5113	15
1 0	9998	0175	89 0	16 0	9613	2756	74 0	31 0	8572	5150	59 0
15	9998	0218	45	15	9600	2798	45	15	8549	5188	45
30	9997	0262	30	30	9588	2840	30	30	8526	5225	30
45	9995	0305	15	45	9576	2882	15	45	8504	5262	15
2 0	9994	0349	88 0	17 0	9563	2924	73 0	32 0	8480	5299	58 0
15	9992	0393	45	15	9550	2965	45	15	8457	5336	45
30	9990	0436	30	30	9537	3007	30	30	8434	5373	30
45	0.9988	0.0480	15	45	0.9524	0.3049	15	45	0.8410	0.5410	15
3 0	9986	0523	87 0	18 0	9511	3090	72 0	33 0	8387	5446	57 0
15	9984	0567	45	15	9497	3132	45	15	8363	5483	45
30	9981	0610	30	30	9483	3173	30	30	8339	5519	30
45	9979	0654	15	45	9469	3214	15	45	8315	5556	15
4 0	9976	0698	86 0	19 0	9455	3256	71 0	34 0	8290	5592	56 0
15	9973	0741	45	15	9441	3297	45	15	8266	5628	45
30	9969	0785	30	30	9426	3338	30	30	8241	5664	30
45	9966	0828	15	45	9412	3379	15	45	8216	5700	15
5 0	9962	0872	85 0	20 0	9397	3420	70 0	35 0	8192	5736	55 0
15	0.9958	0.0915	45	15	0.9382	0.3461	45	15	0.8166	0.5771	45
30	9954	0958	30	30	9367	3502	30	30	8141	5807	30
45	9950	1002	15	45	9351	3543	15	45	8116	5842	15
6 0	9945	1045	84 0	21 0	9336	3584	69 0	36 0	8090	5878	54 0
15	9941	1089	45	15	9320	3624	45	15	8064	5913	45
30	9936	1132	30	30	9304	3665	30	30	8039	5948	30
45	9931	1175	15	45	9288	3706	15	45	8013	5983	15
7 0	9925	1219	83 0	22 0	9272	3746	68 0	37 0	7986	6018	53 0
15	9920	1262	45	15	9255	3786	45	15	7960	6053	45
30	9914	1305	30	30	9239	3827	30	30	7934	6088	30
45	0.9909	0.1349	15	45	0.9222	0.3867	15	45	0.7907	0.6122	15
8 0	9903	1392	82 0	23 0	9205	3907	67 0	38 0	7880	6157	52 0
15	9897	1435	45	15	9188	3947	45	15	7853	6191	45
30	9890	1478	30	30	9171	3987	30	30	7826	6225	30
45	9884	1521	15	45	9153	4027	15	45	7799	6259	15
9 0	9877	1564	81 0	24 0	9135	4067	66 0	39 0	7771	6293	51 0
15	9870	1607	45	15	9118	4107	45	15	7744	6327	45
30	9863	1650	30	30	9100	4147	30	30	7716	6361	30
45	9856	1693	15	45	9081	4187	15	45	7688	6394	15
10 0	9848	1736	80 0	25 0	9063	4226	65 0	40 0	7660	6428	50 0
15	0.9840	0.1779	45	15	0.9045	0.4266	45	15	0.7632	0.6461	45
30	9833	1822	30	30	9026	4305	30	30	7604	6494	30
45	9825	1865	15	45	9007	4344	15	45	7576	6528	15
11 0	9816	1908	79 0	26 0	8988	4384	64 0	41 0	7547	6561	49 0
15	9808	1951	45	15	8969	4423	45	15	7518	6593	45
30	9799	1994	30	30	8949	4462	30	30	7490	6626	30
45	9790	2036	15	45	8930	4501	15	45	7461	6659	15
12 0	9781	2079	78 0	27 0	8910	4540	63 0	42 0	7431	6691	48 0
15	9772	2122	45	15	8890	4579	45	15	7402	6724	45
30	9763	2164	30	30	8870	4617	30	30	7373	6756	30
45	0.9753	0.2207	15	45	0.8850	0.4656	15	45	0.7343	0.6788	15
13 0	9744	2250	77 0	28 0	8829	4695	62 0	43 0	7314	6820	47 0
15	9734	2292	45	15	8809	4733	45	15	7284	6852	45
30	9724	2334	30	30	8788	4772	30	30	7254	6884	30
45	9713	2377	15	45	8767	4810	15	45	7224	6915	15
14 0	9703	2419	76 0	29 0	8746	4848	61 0	44 0	7193	6947	46 0
15	9692	2462	45	15	8725	4886	45	15	7163	6978	45
30	9681	2504	30	30	8704	4924	30	30	7133	7009	30
45	9670	2546	15	45	8682	4962	15	45	7102	7040	15
15 0	9659	2588	75 0	30 0	8660	5000	60 0	45 0	7071	7071	45 0
	Dep.	Lat.	° '		Dep.	Lat.	° '		Dep.	Lat.	° '
	Dist. 1.		Course.		Dist. 1.		Course.		Dist. 1.		Course.

HATHAWAY'S IMPROVED TRAVERSE TABLE, WITH RULES FOR OBTAINING NATURAL SINES, TANGENTS, ANGLES, ETC

~~1896~~

Tolman's New Decimal Scale Measure Protractor is graduated to degrees and whole units of linear measure. The following rules and table are given with reference to the application of the Scale Measure Protractor to diagrams Nos. 3 and 4 in instructions for using the Protractor in constructive geometry and trigonometry. The table shows latitude and departure to four decimal places for linear bearing 1.00 and for angular bearings from 0 to 90 degrees.

If the angular bearing is less than 45 degrees the angle will be found in the 1st., 5th., or 9th. column of the table and the linear bearing at the top or bottom of the column; the latitude will be found in the column headed lat. at the top of the table, and the departure in the column headed dep.

If the angular bearing is more than 45 degrees the angle will be found in the 4th.,8th. or 12th. column of the table The latitude will be found in the column marked lat. at the bottom, and the departure in the column marked dep. at the bottom. The latitude, departure and linear bearings for different distances with the same angular bearings are proportional. Linear bearing = unity, radius, secant and co secant. Latitude = natural sines and tangents. Departure = cosines and co-tangents. Verse sine = the difference in linear bearing and latitude Angular bearings = the number of degrees minutes and seconds that measure the angle.

EXAMPLE FIRST.

Example 1st: Given the angular bearing 11 degrees and 45 minutes and linear bearing 31; required the latitude and departure of the triangle Rule 1st.: In the table opposite 11 degrees 45 minutes we find the decimal .9790 in the latitude column and decimal 2036 in the departure column. Multiply .9790 by bearing 31 = 30.3490; and 2036 by 31 = 6.3116 required latitude and departure.

EXAMPLE SECOND.

Example 2nd: Required the latitude and linear bearing to given linear departure 25 and the angular bearing 19 degrees and 15 minutes. Rule 2nd: In the table opposite to 19 degrees and 15 minutes we find decimal .9441 in the latitude column and .3297 in the departure column Divide the given departure 25 by .3297 =75.8265 the required bearing. Multiply 75.8265 by .9441 = 71 5877 latitude required.

EXAMPLE THIRD.

Example 3rd: Latitude 16 3 4 and angular bearing 37 degrees and 30 minutes given; required linear bearing and departure. Rule 3rd: in the table opposite to 37 degrees and 30 minutes in latitude column we find decimal .7934 and .6088 in departure column. Divide the given latitude 16.34 by .7934 = 20.5949 the required bearing, and multiply the linear bearing 20.5949 by .6088 = 12.5381 the required departure.

Bearing 600

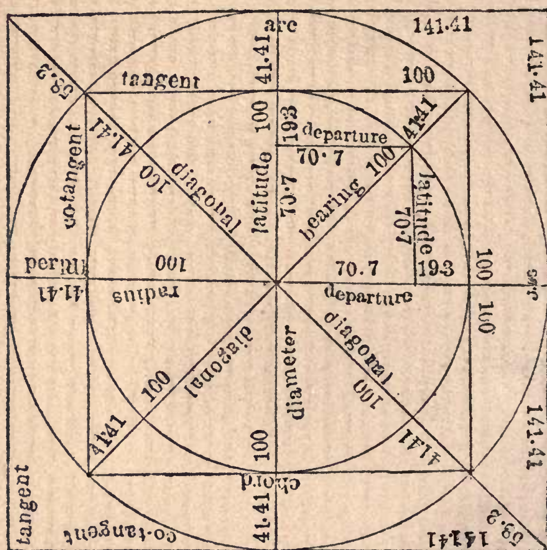
EXAMPLE FOURTH.

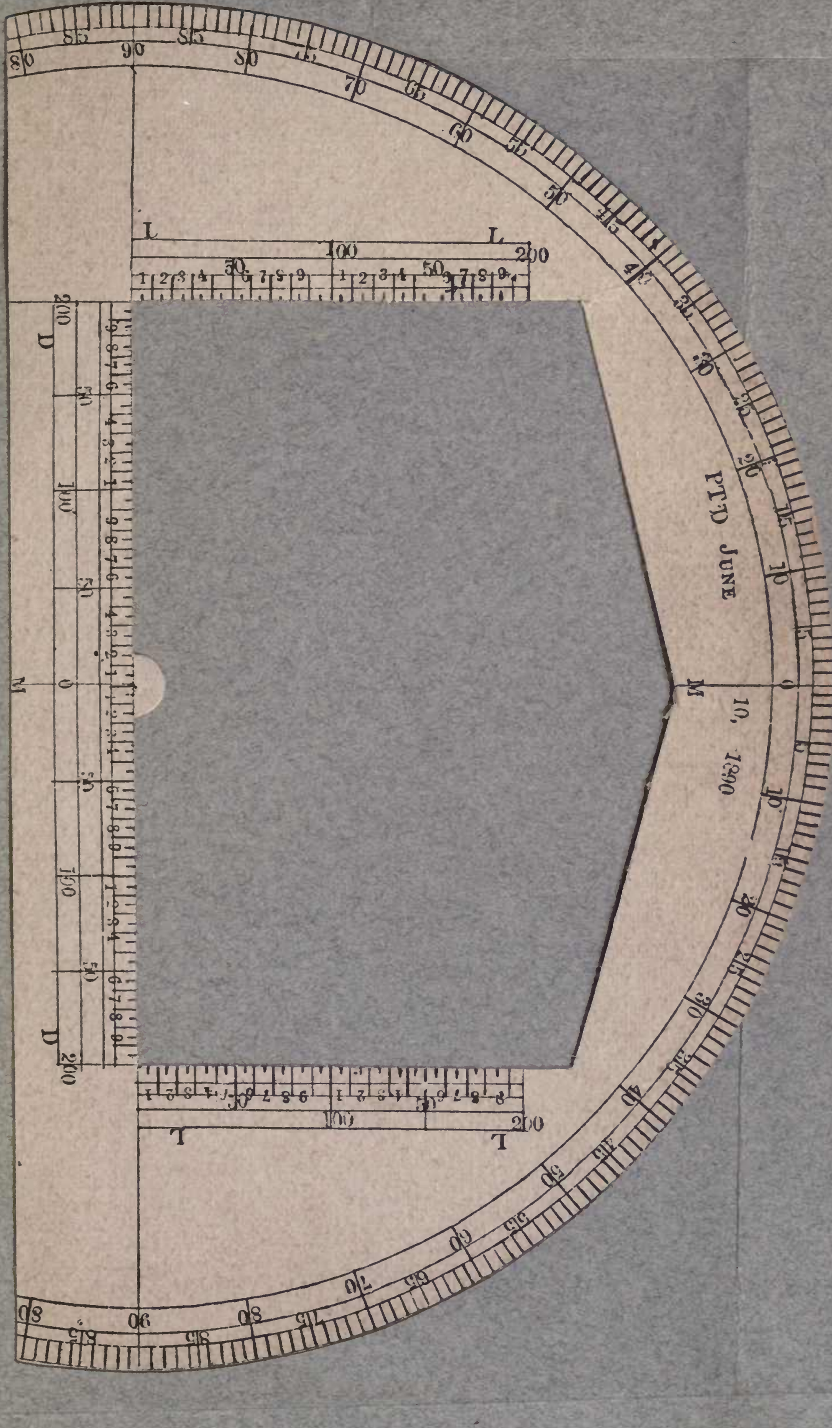
Example 4th : Given linear bearing 600 and linear departure 100: required the angular bearing. Rule 4th: divide the given departure 100 by given [redacted] 600 =.1666. In the table we find the nearest number to the quotient to be the decimal .1650 opposite to 9 degrees and 30 minutes, and .1693 opposite to 9 degrees and 45 minutes, subtracting the quantities we have 15 minutes equals .0043; divide .0043 by 15 minutes equals .00028666 the tabular difference for 1 minute. Subtract .1650 from 1666 equals .0016 divided by .00028666 equals 5.5815 minutes. .5815 multiplied by 60 equals 34.89 seconds. Combining the quantities we have 9 degrees, 35 minutes and 34.89 seconds for the required angular bearing.

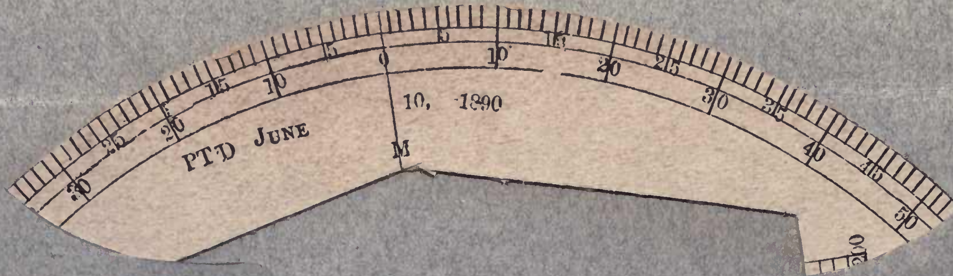
EXAMPLE FIFTH.

Example 5th: First operation: Required the verse sine, (the verse sine is the difference between the latitude and linear bearing) for linear bearing 31 and angular bearing 11 degrees and 45 minutes. By rule 1 we find the latitude to be 30.3490. subtract, and the difference .6510 is the verse sine: Second operation: required co-tangent to the same linear and angular bearing The given bearing 31 becomes latitude and is worked by rule 3rd. The co-tangent is 6.4469 and the co-secant 31.6650; third operation: required the natural tangent and secant to the same linear and angular bearing. Substitute the linear bearing 31 for latitude to natural tangent and secant. The angular bearing of the tangent and secant is found by subtracting the given angle 11 degrees and 45 minutes from 90 degrees equals 78 degrees and 15 minutes, therefore read the columns from the bottom and proceed as in rule 3rd. tangent is 149.0618, and the secant 152.2593.

The latitude and departure given to find linear bearing: rule square the latitude and departure add them and extract the square root.


arc
141.41
41.41
tangent
100
193
departure
70·7
latitude
bearing
diagonal
cotangent
perm
radius
diameter
chord
co-tangent
59.2
141.41


PTD JUNE 10, 1890


PT'D JUNE 10, 1890
M
30 25 20 15 10 5 0 5 10 15 20 25 30 35 40 45 50